

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁵ :

(11) International Publication Number:

WO 90/00420

A61N 5/06

AI

(43) International Publication Date:

25 January 1990 (25.01.90)

(21) International Application Number: PCT/GB89/00796

(22) International Filing Date: 13 July 1989 (13.07.89)

(30) Priority data:
8816648.3 13 July 1988 (13.07.88) GB

(71)(72) Applicants and Inventors: ROWLAND, Adrian, Charles [GB/GB]; 13 Mary Ann Gardens, London SE& 3DP (GB). ALLARDICE, James, Todd [GB/GB]; 1G Gainsborough Square, Bexleyheath, Kent DA6 8BU (GB).

(74) Agents: WILLIAMS, Trevor, John et al.; J.A. Kemp & Co., 14 South Square, Gray's Inn, London WC1R 5EU (GB).

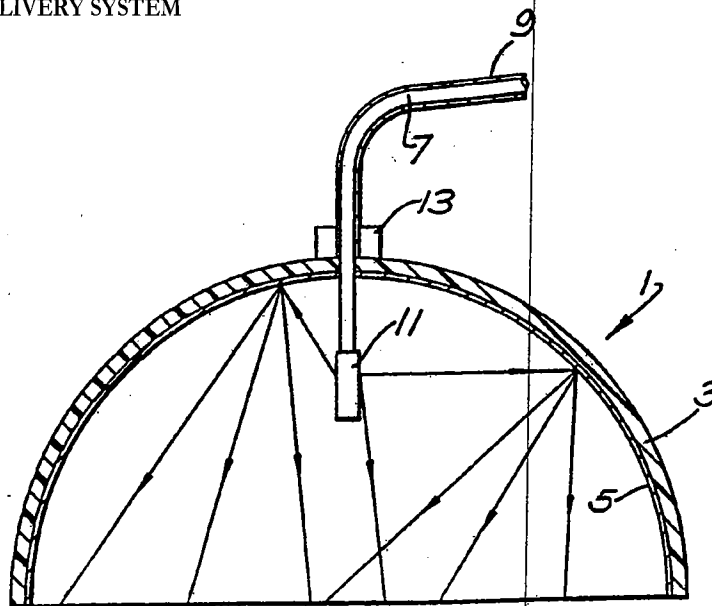
(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), C, MG, ML (OAPI patent), MR (OAPI patent), MW, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published

With international search report

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments

(54) Title: LIGHT DELIVERY SYSTEM



(57) Abstract

A device for uniformly irradiating an area of a surface which accurately defines the area under irradiation and collects lights reflected from the area and scatters it back towards the surface. The device comprises a hemispherical shell (3) whose inside surface is coated with a diffuse reflector and a light source (11) mounted in the shell (3). The light source may be a diffusing device connected to a laser remote from the shell (3) via an optical fibre (7). In use the shell (3) is placed against the surface under illumination so that the edges of the shell (3) define the area under illumination and the use of the diffusely reflecting surface of the shell (3) prevents any escape of light. A deformable sheet of partly reflective and partly transmissive material may be placed across the open mouth of the hemisphere to cover the target area to increase the uniformity of illumination when the device is used on uneven surfaces. The device is particularly useful in photodynamic therapy.

defines the area under irradiation and collects lights reflected from the area and scatters it back towards the surface. The device comprises a hemispherical shell (3) whose inside surface is coated with a diffuse reflector and a light source (11) mounted in the shell (3). The light source may be a diffusing device connected to a laser remote from the shell (3) via an optical fibre (7). In use the shell (3) is placed against the surface under illumination so that the edges of the shell (3) define the area under illumination and the use of the diffusely reflecting surface of the shell (3) prevents any escape of light. A deformable sheet of partly reflective and partly transmissive material may be placed across the open mouth of the hemisphere to cover the target area to increase the uniformity of illumination when the device is used on uneven surfaces. The device is particularly useful in photodynamic therapy.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁵: A61N 5/06 (11) International Publication Number: WO 90/00420
(43) International Publication Date: 25 January 1990 (25.01.90)

(21) International Application Number: PCT/GB89/00796

(22) International Filing Date: 13 July 1989 (13.07.89)

(30) Priority data: 8816648.3 13 July 1988 (13.07.88) GB

(71)(72) Applicants and Inventors: ROWLAND, Adrian, Charles [GB/GB]; 13 Mary Ann Gardens, London SE8 3DP (GB). ALLARDICE, James, Todd [GB/GB]; 10 Gainsborough Square, Bexleyheath, Kent DA6 8BU (GB).

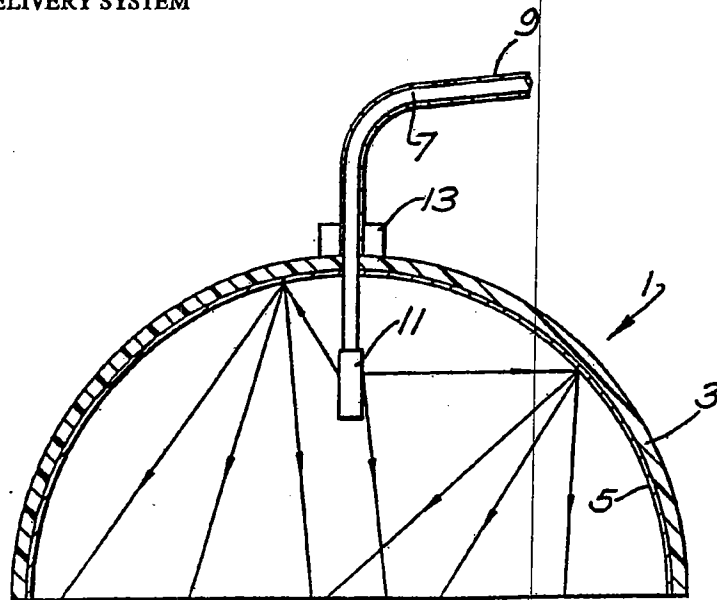
(74) Agents: WILLIAMS, Trevor, John et al.; J.A. Kemp & Co., 14 South Square, Gray's Inn, London WC1R 5EU (GB).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, L, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published

With international search report
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments

(54) Title: LIGHT DELIVERY SYSTEM



(57) Abstract

A device for uniformly irradiating an area of a surface which accurately defines the area under irradiation and collects lights reflected from the area and scatters it back towards the surface. The device comprises a hemispherical shell (3) whose inside surface is coated with a diffuse reflector and a light source (11) mounted in the shell. The light source may be a diffusing device connected to a laser remote from the shell (3) via an optical fibre (7). In use the shell (3) is placed against the surface under irradiation so that the edges of the shell (3) define the area under illumination and the use of the diffusely reflecting surface of the shell prevents any escape of light. A deformable sheet of partly reflective and partly transmissive material may be placed across the open mouth of the hemisphere to cover the target area to increase the uniformity of illumination when the device is used on uneven surfaces. The device is particularly useful in photodynamic therapy.

<p style="text-align: center;"><i>FOR THE PURPOSES OF INFORMATION</i></p> <p>Codes used to identify States party to the PCP on the front pages applications under the PCP.</p> <table><tr><td>AT Austria</td><td>FS Spain</td><td>MG Madagascar</td></tr><tr><td>AU Austria</td><td>FT Finland</td><td>ML Mali</td></tr><tr><td>BR Barbados</td><td>FR France</td><td>MR Mauritania</td></tr><tr><td>BE Belgium</td><td>GA Gabon</td><td>MW Malawi</td></tr><tr><td>BF Burkina Faso</td><td>GB United Kingdom</td><td>NL Netherlands</td></tr><tr><td>BG Bulgaria</td><td>HU Hungary</td><td>NO Norway</td></tr><tr><td>BI Benin</td><td>IT Italy</td><td>RO Romania</td></tr><tr><td>BR Brazil</td><td>JP Japan</td><td>SD Sudan</td></tr><tr><td>CA Canada</td><td>BP Democratic People's Republic of Korea</td><td>SE Sweden</td></tr><tr><td>CF Central African Republic</td><td>KR Republic of Korea</td><td>SI Senegal</td></tr><tr><td>CG Congo</td><td>u Liechtenstein</td><td>SU Soviet Union</td></tr><tr><td>CFL Switzerland</td><td>LK Sri Lanka</td><td>TD Chad</td></tr><tr><td>DE Germany, Federal Republic of</td><td>WL Luxembourg</td><td>TG Togo</td></tr><tr><td>DK Denmark</td><td>MC Monaco</td><td>US United States of America</td></tr></table>		AT Austria	FS Spain	MG Madagascar	AU Austria	FT Finland	ML Mali	BR Barbados	FR France	MR Mauritania	BE Belgium	GA Gabon	MW Malawi	BF Burkina Faso	GB United Kingdom	NL Netherlands	BG Bulgaria	HU Hungary	NO Norway	BI Benin	IT Italy	RO Romania	BR Brazil	JP Japan	SD Sudan	CA Canada	BP Democratic People's Republic of Korea	SE Sweden	CF Central African Republic	KR Republic of Korea	SI Senegal	CG Congo	u Liechtenstein	SU Soviet Union	CFL Switzerland	LK Sri Lanka	TD Chad	DE Germany, Federal Republic of	WL Luxembourg	TG Togo	DK Denmark	MC Monaco	US United States of America	pamphlets publishing international	
AT Austria	FS Spain	MG Madagascar																																											
AU Austria	FT Finland	ML Mali																																											
BR Barbados	FR France	MR Mauritania																																											
BE Belgium	GA Gabon	MW Malawi																																											
BF Burkina Faso	GB United Kingdom	NL Netherlands																																											
BG Bulgaria	HU Hungary	NO Norway																																											
BI Benin	IT Italy	RO Romania																																											
BR Brazil	JP Japan	SD Sudan																																											
CA Canada	BP Democratic People's Republic of Korea	SE Sweden																																											
CF Central African Republic	KR Republic of Korea	SI Senegal																																											
CG Congo	u Liechtenstein	SU Soviet Union																																											
CFL Switzerland	LK Sri Lanka	TD Chad																																											
DE Germany, Federal Republic of	WL Luxembourg	TG Togo																																											
DK Denmark	MC Monaco	US United States of America																																											

- 1 -

LIGHT DELIVERY SYSTEM

This invention relates to an apparatus and method for illuminating an area of an object and in particular to a device in which the total amount of luminant energy delivered to the area can be accurately determined. It is particularly applicable to medical treatment techniques which rely on the illumination of body tissue in order to achieve desired effects e.g. photodynamic therapy and bio-stimulation.

It has been found that certain types of cancer including skin cancer and breast cancer can be treated successfully using a technique known as photodynamic therapy or PDT. In this technique a photosensitizing agent, usually haematoporphyrin derivative (HpD) is administered to the patient and this agent concentrates in the cancerous tissue. It is thought that the agent concentrates in the tumour because it leaks out of the vasculature in the tumour into the surrounding tumour tissue. The lymphatic system within the tumour is not as efficient at removing the HpD as is the lymphatic system in the rest of the body and so for a certain time period there is proportionately more HpD in the tumour than in the rest of the body. At some point in that time period the area of the body with the tumour is irradiated with laser light having a wavelength of about 630

nm! from! an! argon aye laser. '! The! effec of! the! laser! light
on! the! OpD! is! to! cause! oxygen! radicals to! be! released! which
destroy! the! surrounding! tumour! tissue. In! the! case! of
breast! cancer! the! illumination! stage! o the! treatment is
usually! given! twenty-four! to! seventy-two! hours! after
administration! of! the! HpD! agent,! though with! skin! cancer,
laser treatment! can! be delivered! up! to three! or! four! weeks
after! the! administration! of! the! HpD.

Conventionally! the! treatment! a! ea! has! been
illuminated! using! laser! light! directed down! an! optical
fibre,! the! tip! of! the! fibre! being! moved over! the! treatment
area. One! problem! with! this! method! is that! the! illumination
consists! of! an! intense! centre! spot! with the! intensity
falling! away! gradually! from! the! centre of! the! spot.! This
means! that! it! is! difficult! to! give! an! even! dosage! of! light
to! a! large! area_! Furthermore,! it! is! vry! easy! to! apply! too
much! light! to! some! areas.! In! order! to! attempt! to! alleviate
this! problem! it! has! been! proposed! to! deliver! the! light! using
an! optical! fibre! bundle! with! micro-lenses! on! the! end! of! each
fibre! or! diffusers! in! the! light! path! to! give! a! broader,! more
even,! illumination! 'area. Another! proposal! is! to! control! the
intensity! profile! of! the! beam! emerging! from! an! optical! fibre
by! interposing! an! oblique! glass! plate! between! the! laser! and
the! optical! fibre.

A! further! problem,! which! also! occurs! with! the

-! 3! -

improved techniques mentioned above, **is**, however, that since the surface of the body being illuminated **is** to some extent reflective, it is difficult to determine exactly how much light is absorbed to act on the HpD. The reflectivity of different parts of the treatment area may vary and so even dosage estimates based on an estimated or measured reflectivity are not particularly good. A typical dosage estimate with one of the techniques above was that 30-400 J/cm² was delivered to the patient. It can be seen that the upper limit of the range is over ten times the lower limit and this is unsatisfactory both from the point of view of that treatment and for statistically processing the results from many treatments to try to improve the technique.

It has also been proposed to use laser light in other medical treatments, e.g. bio-stimulation in which tissue is irradiated with low power laser light. It has been suggested that this irradiation has certain beneficial effects and has been used to speed-up the healing of wounds, as a beauty treatment and in physiotherapy. Laser illumination has also been used in the treatment of vascular **abnormalities** such as port wine stain and the removal of tattoos. Other types of light **have** also been used, for instance, infra **red** or **ultra violet** for treating various conditions e.g. the treatment of skin disorders e.g. psoriasis. In some of these agents which render the **skin**


4! -

sensitive! to! the! particular! light! bein^g used! have! been
administered to! the **patient**. **However**, similar! problems! with
achieving! a! uniform **illumination** and! calculating! the! amount
of! light! delivered! to! the! surface! have! been! found.

The! present! invention! provides! a! device! to! deliver! a
defined **quantity** of! light! to! a **surface! comprising** a! light
source! for! illuminating! the! surface! and! means! for! scattering
light! reflected! from! the! surface! so! that! it! can! be! directed
back! onto! the! surface.! Preferably! the! scattering! means! are
adapted! to! provide! ..a! substantially! uniform! illumination! of
the! surface.

In! more! detail! the! present! invention! provides
apparatus! for *illuminating* an! area! of! an! object,! comprising
a! delivery! device! including! a! light! source! for! illuminating
the! area! and! a! concave *diffusely* reflecting *surface*, wherein
the! diffuse! reflecting! surface! is! adapted! to! define! the! area
to! be! illuminated! when! the! device! is! held! in! contact! with
the! object! and! to! collect! light! reflected! from! the! surface
of the! object! and! scatter! it! back! towards! the! area.

Preferably! the! light! source,! which! conveniently! is
the! tip! of! an! optical! fibre,! is! arranged! to! illuminate! the
diffusely! reflective! surface! so! that! light! from! the! light
source! is! reflected! towards! the! treatment! area.! This! can! be
achieved! by! diffusing! the! light! with,! for! example, a ceramic
reflector! or! possibly! a! p.t.f.e.! or! etched! diffuser! on! the



-! 5! -

optical! fibre. |

The! present **invention** also! pro **ides! a** method! of
illuminating! an! area! of! an! object! comp! ising! the! steps! of:

illuminating! the! area! of! the! o! ject! with! light! from
a! light! source! illuminating! a **concave** iffusely! reflective
surface! maintained! confronting! the! are

positioning! the! diffusely! refl! cting! surface! with
its! edges! in! contact! with! the! objects! that! it! collects
light! reflected! from! the! surface! of! th! object! and.! scatters
it! back! towards! the! area! and! so! that! t! e! edges! of! the
concave! diffusely! reflecting! surface! d! fine! the! area! being
illuminated.

The! light! used! may! be! laser! li! ht! as! in! the
conventional! PDT! techniques! or! may! be! on-coherent! light! for
some! applications. The! diffusely! refl! ctive! surface! may! be
the inner,! concave! surface! of a part-s 'herical, e.g.
hemispherical,! shell-like! structure! wi! h! the! optical! fibre
and! diffusing! device! attached! in! its! t•p.! In! use,! the! shell
is! held! with! its! edges! in! contact! with! the! object! under
illumination! so! that! any! light! reflect! =d! off! the! illuminated
area! is! collected **and! scattered! back t ere to! by** the
diffusely! reflective! surface. A! refle•tivity! of! 99%! can! be
achieved! by! coating! the! concave! surfac! with! reflective
paint,! or! any! suitable! highly! reflecti! e! coating,! e..g.! a
ceramic.

If the area to *be* illuminated is smaller than the base area of the hemisphere then parts of the area which do not require illumination can be masked with a highly reflective surface. This means that light striking the reflective surface is not lost but is reflected back towards the diffusely reflective surface and a *entually-onto* the area to be illuminated.

It will be appreciated that with the present invention the amount of light delivered to the treatment area can be accurately determined since none of the light delivered to the area is allowed to escape. This is because almost all of the light reflected from the illuminated area is scattered back towards it by the diffuse reflective surface and since the reflective surface is held in contact with the object, no light can escape under the edges. Furthermore, the use of a diffusing device on the end of the optical fibre delivering the laser light and the use of the diffusely reflective surface mean that the intensity of the illumination is **substantially** uniform over the whole of the treatment area.

The invention also has benefit for the safety of the operator and, if it is being used in medical treatment, for the patient, as once the reflective surface is in contact with the body the laser system is closed and there is very little risk of accidental injury to the operator or

to! the! patient! caused! by! escaping! las! r! light.! It! is possible! to! arrange! for! the! laser! or! cther! light! source! only to! be! switched! on! when! the! reflective! surface! is! placed! in contact! with! the **body!** - e.g.! by! a! pressure! sensitive! or temperature **sensitive! switch! or** by! some **other** switching means.

If! desired! the! target! to! be! illuminated! may! be treated! with! an! agent! to! absorb! the! light.! e.g.! a **photodegradable** or! photocensitizing! agent.! For! example where! the! invention! is! to! be! used! in! photodynamic! therapy, e.g.! for! the! treatment! of! cancer,! then! a! suitable! agent which! might! be! preferentially! absorbed! by! certain! cells! e.g. cancerous! cells,! e.g. *HpD* can! be! administered! to! the! patient some! hours! before! the! laser! treatment.! An! accurate! amount of! light! can! then! be! delivered **to** the! treatment! area! and this! allows! the! operator! to! calculate! more! accurately! what depth! of! tissue! may! be! destroyed.! This! not! only! allows better! treatment **of** an **individual** pati! nt! but! also **allows** a better! correlation-! of! results! to! treat! ent! conditions! and! so the! best! conditions! for! the! treatment! f! the! cancer! and different! types **of** cancer! may! be! determined! more! easily.

The! invention! is! also! useful! fr! the! treatment! of port! wine! stains, **homeopathic** processe! and! bio-stimulation where! the! fact **that** the **illumination** i uniform **and! defined** allow! better! control! of! the! treatment 'rocess.

-! 8! -

The! invention! has! been! describ
to! use! in! medical! treatment,! e.g.! for-
It! is,! however,! useful! in **any** process
to! uniformly! illuminate! an! area! and! to
by! reflection! from! that! area.! Thus! th
in! industrial! processes! for! manufactur
substances! e.g.! plastic! resin! composit
processes! in! the! manufacture! of! electr
microchips. In! such! processes! the! fac
escapes! and! that! a well! defined! area! i
that! the! process! can! be! run! economical
processes! types! of! electromagnetic! rad
optical! laser! light! might! be! appropria

The! device! may! also! be! useful
biological! growth! of **animals** ox! partic
again! the! fact! that! the! illumination! i
and! no! radiation! is! allowed! to! escape
efficiency! and! economy! of! the! process.

The! shape! of! the! reflective! su
to! be! particularly! critical,! the! prefer
this! specification! uses! a! hemisphere! bu
shapes! can! be! used.

The! size! of! shell! is! chosen! to
of! the! area! to! be! illuminated.

A! typical! size! of! shell! used! for! medical! purposes

d! above! in! relation
hotodynamic! therapy.
here! it! is! desirable
avoid! loosing! light
device! could! be! used ,
e.g.! for! curing
s! or! for! optical
nic! devices! e.g.
that! no! light
illuminated! mean
y. Clearly! for! such
ation! other! than
e.

or! promoting
larly! plants,! where
accurately! defined
an! improve! the

face! is! not! thought
red! embodiment! in
t! other! concave

-! 9! -

would be a few inches in diameter, but **larger or smaller**
shells, e.g. large enough to cover the **complete pelvic area,**
may also be used where appropriate. I **is also possible for**
the reflective surface to be formed on **a flexible** member so
that it can be **shaped** to match the shape of the area to be
treated. These allow the operator to void treating areas
which do not need treatment.

As an alternative to using a diffusing device on the
end of the optical fibre, the fibre may be mounted to direct
light onto a diffuse reflector, made from, e.g. a reflective
ceramic, mounted in front of the diffusely reflective
surface to reflect the light back onto it.

The apparatus may further comprise a deformable
sheet of material across the open end of the concave
surface, e.g. a sheet of white rubber or synthetic rubber,
and which has a high reflectivity, appreciable transmission
and low-absorption. The absorption should be low enough to
prevent undesirable light loss, e.g. about 1%, and the
transmission high enough to allow sufficient illumination of
the target surface. For medical applications about 9% is
acceptable. The reflectivity should be for such
applications, about 90%.

The **invention** will be **further** described **by** way of
non-limitative example with reference to the **accompanying**
drawings which: -

- 10 -

Figure 1 is a cross-sectional view of one embodiment of the invention;

Figure 2 is a partially cutaway view of the embodiment of Fig 1 in use;

Figure 3 is a schematic view of a second embodiment of the invention in use;

Figure 4 shows a third embodiment of the present invention; and

Figure 5 shows a fourth embodiment of the invention

As can be seen by Fig 1 the apparatus comprises a light delivery device 1 which consists of a hemispherical relatively rigid, plastics shell 3 whose inside, concave surface is coated with a reflective coating 5. The coating is a reflective paint or ceramic which provides a diffuse reflective surface. It is possible to achieve a reflectivity as high as 99% or more with such a coating. The shell, intended for medical use in PDT is about 5-15cm in diameter and about 1-2mm thick.

Laser light is supplied to the device along an optical fibre 7, which may be a single fibre or a bundle of fibres. In this embodiment the fibres are teflon coated and retained within a p.t.f.e. sheath 9. The fibres terminate at a diffusing element 11, which is in this embodiment a p.t.f.e. cylinder or, alternatively, a ceramic or etched fibre diffuser (formed by exposure to hydrofluoric acid)

11! -

mounted in the **hemispherical** shell. The fibre is connected to the shell by a two-part block 13 having a bore *down* the centre through which the fibre and sheath pass. **The fibre** is trapped in an interference fit between the two parts of the block 13. In the illustrated embodiment the diffuser 11 is positioned about 2cm below the top of the shell. Light transmitted down the fibre passes into the diffuser 11 and is emitted from the end **of** the diffuser in a number of directions. Some light will be transmitted directly to the treatment surface, but some light **will** also be transmitted towards the diffusely reflective surface 5. Various light paths are shown in the diagram. Light striking the diffusely reflective surface will be scattered therefrom, partly towards the treatment area and partly towards opposing regions of the reflector. It will be appreciated, therefore, that a fairly uniform illumination is achieved within the region defined by the edges of the reflective shell.

Although not shown in the diagram, the shell may be provided with a sensor and switch so that the laser supplying light to the optical fibre is only switched on when the shell is pressed into contact with the surface which is to be illuminated. This results *in* less chance of the patient or operator being accidentally exposed to laser light and thus improves the safety of the apparatus.

- 12. -

In Fig. 2 the device is shown schematically in use on part of a patient 15. This shows the device used in a situation where the area 17 which is to be illuminated is **smaller than the base area of the reflector**. The **parts of skin which would undesirably be exposed to the light have therefore been masked using a reflective tape 19, -for example, aluminium tape**. This means that light supplied to the delivery device 11 which misses the **exposed treatment area** and hits the tape is reflected back up to the **diffusely reflective surface** and scattered back towards the treatment area.

Figure 3 shows a second embodiment of the invention in use. In this embodiment the reflective shell 22 is formed from a flexible plastics material so that it may be deformed to cover a desired treatment area more accurately. A further feature of this embodiment, which can also be used in the other embodiments of the invention, is that light is supplied to the device by several optical fibres 27 **each** connected to a diffusing device 11 and spaced over the surface of the shell. This enables a greater amount of light to be delivered per unit time if necessary and helps in maintaining a substantially uniform light distribution **particularly** in the case where the shell is deformed.

The above embodiments have been described as being supplied with laser light by an optical fibre. However, the

- 13! -

invention is! also usable in! other applications! in! which! e.g. ultra! violet! or! infra! red! light! or! any! electromagnetic! wave radiation! are! used.! in! such! applications! the! light! may! be delivered! to! the! delivery! device! using! a! light! guide! e.g. liquid! or! fibre! light! guide! or! other! t! pes! of! radiation guides! or! the! light! source! may! be! moun! ed! in! or! on! the shell.

Figure 4! shows! schematically a! third! embodiment of the invention in! which! light delivered to! the *device by* an optical! fibre! 9! is! directed! onto! a! ref! ector! 30! in! this! case spherical,! though! other! shapes! may! be! sed,! which! reflects light! back! upon! to! the! diffusely! refle! tive! surface! which, in! turn,! scatters! it! onto! the! treatmen! area.! The! reflector 30,! which! may! be! a! highly! reflective! c! ramic,! is! mounted! on the! shell! 1! by! a! mounting! 32.

Figure! 5! shows! disgrammaticall! a! fourth! embodiment of! the! invention! which! uses! a! reflecto! 1! and! light! delivery system! 9! and! 30! as! in! the! previous! emb•diments,! but! also includes! a! deformable! partly! reflectiv=! partly! transmissive sheet! 50! across! the! open! end! of! the! reflector! which,! in use,! covers! the! target! area.! The! sheer! 50! may! be! a! sheet! of white! rubber! or! synthetic! rubber! and! h-s! a! high! reflectance preferably! greater! than! 17%! and! more! p! eferably! still greater! than! 77%! ,! very! low! absorttion! •referably! less! than 5%! and! appreciable! transmission. Typi.al! values! which! have

-! 14! -

been! **effective** in! practice! are,! for! in! tance, . 90%
reflection, 9% transmission *and* 1% absorption.! This! sheet
50! is **particularly** useful! when! the! dev! ce! is! used! to
illuminate! an **uneven! surface! as** it! con **orms! or! partly**
confirms to that! surface! and! improves she! uniformity! of! the
light! delivered! to! the! target.

5

With! the *invention* it! is! possitle! to! calculate! the
amount! of! light! supplied! to! the! treatment! area! much! more
accurately! than! with! the! prior! art! devices.! This **is** because
substantially all! of! the! light! supplied! to! the! device! is
eventually! absorbed! by! the! treatment! surface.! None! is
allowed! to! escape! -! because! the! reflector! shell! is! placed! in
contact! with! the! object! being! illuminated! and! any! light
reflected! from! the! treatment! surface! is **eventually** scattered
back! by! the! diffuse! reflector! towards! t! e! treatment! surface.
Furthermore,! the! fact,! that! virtually! n! ne! of! the! light
supplied! to! the! device! is! allowed! to! es! ape! means! that! the
device! is! particularly! safe! to! use.

While! the! invention! has! been! de! cribed! in! relation
to! the! medical! treatments,! as! discussed! above! it! is
applicable! wherever! it! is! required! to! deliver! an! accurate
and! uniform! irradiation! to! a! surface,! or! to! substantially! .
reduce! the! amount! of! light! lost! from! a! system,! or! to! define
the **area** to! which **radiation! should! be! delivered.** The! effect
of! this! device! in! minimizing! losses! has benefits! in! that! for

-! 15! -

a! given! total! energy! absorption! requir! ment! for! a! given
power! output! of! the! radiation! source,! less! time! will! be
needed! to! bring! about! that! effect.

- 16 -

CLAIMS

1. **Apparatus to deliver a defined quantity of light to a surface comprising a light source for illuminating the surface and means for scattering light reflected from the surface so that it can be directed back onto the surface.**

2. **Apparatus according to claim 1 wherein the scattering means are adapted to provide a substantially uniform illumination of the surface.**

3. **Apparatus for illuminating an area of an object, comprising a delivery device including a light source for illuminating the area and a concave diffusely reflecting surface, wherein the diffusely reflective surface is adapted to define the area to be illuminated when the device is held in contact with the object and to collect light reflected from the surface of the object and scatter it back towards the area.**

4. **Apparatus according to claim 3 wherein the light source is adapted to illuminate the diffusely reflective surface so that light from the light source is scattered towards the area of the object.**

5. **Apparatus according to claim 3 or 4 wherein the light source is a source of laser light**

6. **Apparatus according to claim 3, 4 or 5 wherein**

-! 17! -

the! light! source! includes! an! element! for! distributing! the
light! onto! the! reflecting! surface.

7. Apparatus! according! to! cl! im! 6! wherein! the
element! is! a! diffusely! reflecting! body

8. Apparatus! according! to! claim! 6! wherein! the
element! is! a! p.t.f.e.! cylinder.

9. Apparatus according! to! an! one! of! the! preceding
claims! wherein! the! diffusely! reflectiv! surface! is! the
concave! surface! of! a! shell-like! struct! re,! the! edges! of! the
shell! defining! the! area! to! be! illuminated! when! it! is! held! in
contact! with! the! object.

10. Apparatus! according! to! claim! 9! wherein! the
concave! surface! is! coated! with! a! reflective! ceramic! to! form
the! diffusely! relect.ive! surface.

11. Apparatus! according! to! anj one! or! the! claims! 3
to! 10! further! comprising! a! deformable heet! of! material
across! the! open-end! of! the! concave! surf ace,! said! material
having! a high! light! reflectance, **apprec** iable! light
transmission! and! low! light! absorption! flor! the! light! from
said light! source.

12. A! method! of! illuminating! an! area **of** an! object
comprising! the! steps! of:

illuminating the! area! of! the! object! with! light! from
a! light! source! preferably! a! laser! light! source,! illuminating
a! concave! diffusely! reflective! surface! maintained

- 18! -

confronting! the! area,

and! positioning! the! diffusely! efecting! surface
with! its! edges! in! contact! with! the! object! so! that! it
collects! light! reflected! from! the! surf-ce! of! the! object! and
scatters! it! back! towards! the! area! and! o! that! the! edges! of
the! concave! diffusely! reflecting! surfa! e! define! the! area
being *illuminated*.

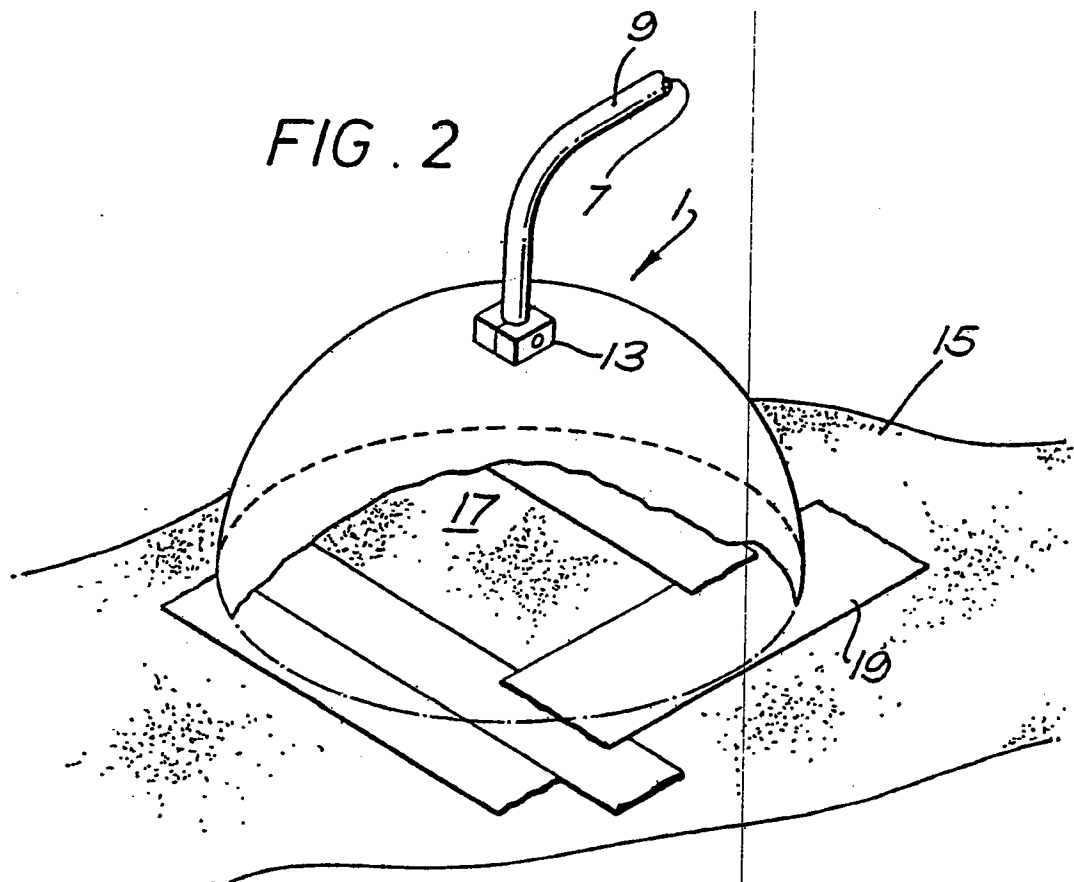
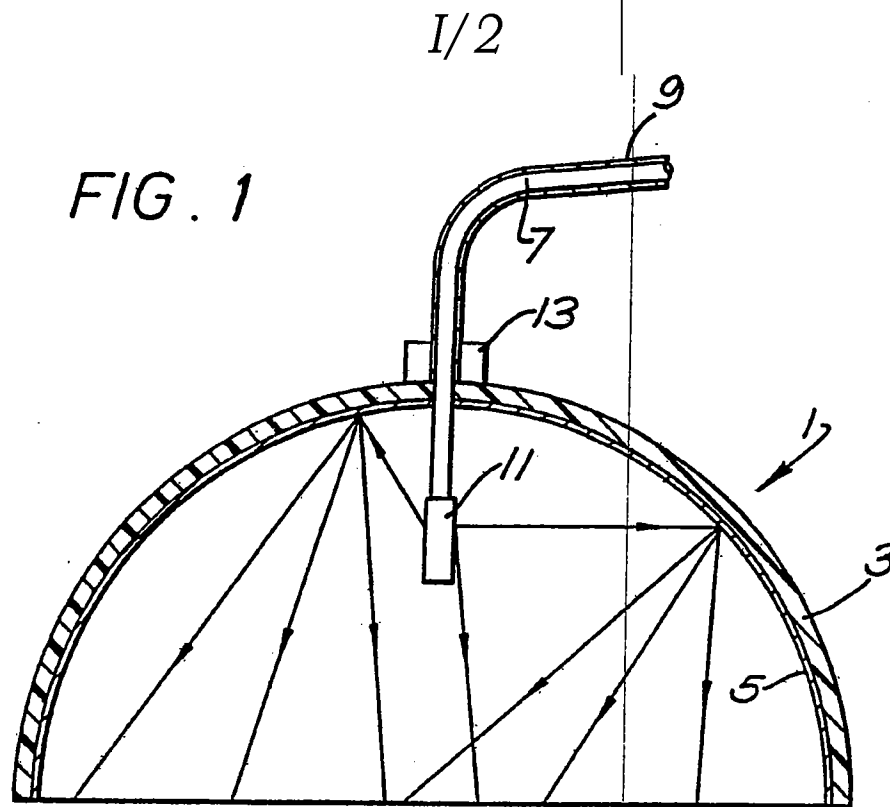
b

13. A! method! according! to! cia 12! wherein! the
diffusely! reflecting! surface! is! illumi! ated! by! light
delivered! by! an! optical! fibre! to! a! dif! user,! e.g.! of! ceramic
or! a! p.t.f.e.! cylinder,

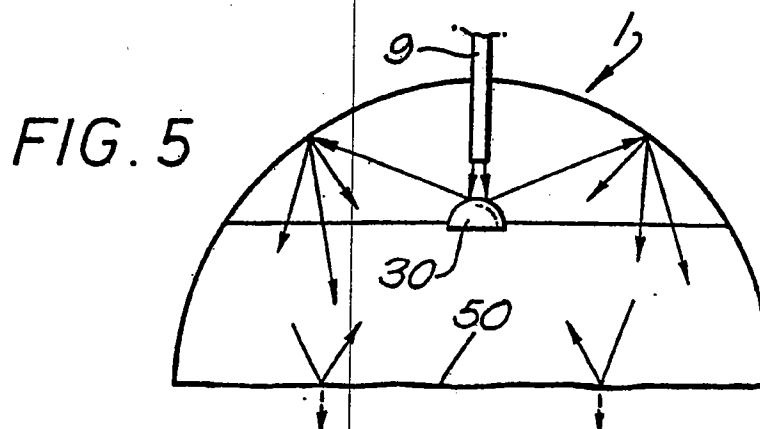
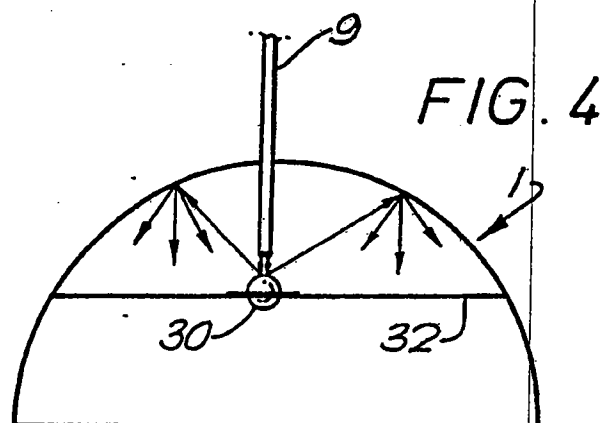
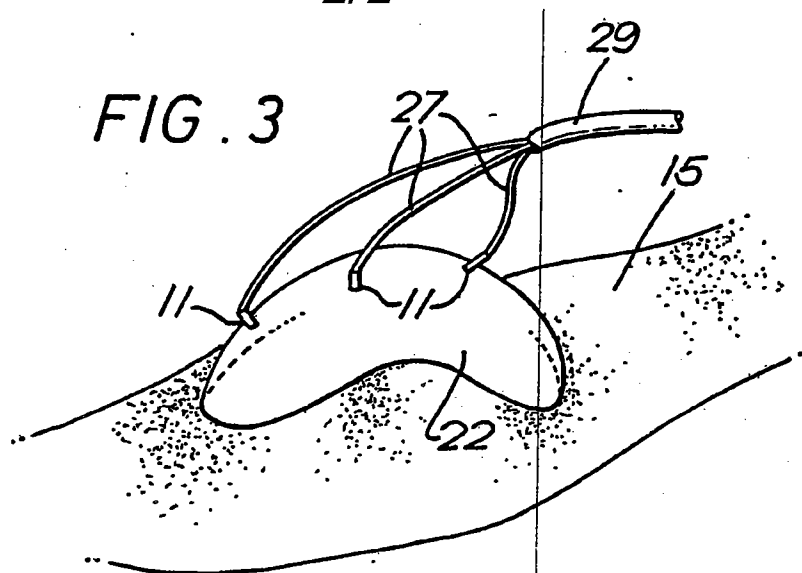
14. A! method! according! to! claim! 12! or! 13! wherein
the! area! is! provided! of! with! a! degradable! agent! for
absorbing! the! light.

15. A! method! according! to! cla 12,13! or! 14,
wherein! light! from! the! concave! surface! is! transmitted
through! a! deformable! sheet! covering! th! surface,! the! sheet
having! properties! of! high! light! reflec! ance,! appreciable
light! transmission! and! low! light! absor! tion.

||



2/2



INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 89/00796

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ^r			
According to International Patent Classification (IPC) or to both National Classification and IPC			
Ipc5: A 61 N 5/06			
ii. FIELDS SEARCHED			
Minimum Documentation Searched ⁷			
Classification System		Classification Symbols	
IPC5		A 61 N, A 61 B	
Documentation Searched other than Minimum Documentation to the Patent that such Documents are Included In the Fields Searched ⁸			
iii. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹			
Category ¹⁰	Citation of Document, ¹¹ with Indication where appropriate of the relevant passages ¹²	Relevant to Claim No. ¹³	
X	FR, A 2591902 (COLLIN) 26 June 1987, see page 3, lines 28-32; page 6, figure 4 --	1-5, 9, 12	
X	D.E, A 3300517 (MERSMANN) 26 July 1984, see page 9, lines 12-20; page 52, lines 32-37; page 99, lines 9-33; figures 93-96	1-10, 12	
<p>Special categories of cited documents: ¹⁴</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"L" document which may throw doubts on priority claims or which is cited to establish the publication date of another citation or for other special reasons (as specified)</p> <p>"O" document referring to an oral disclosure, user, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document cited to show that the invention is not novel</p> <p>"Y" document cited to show that the invention is not inventive</p> <p>"3" document cited to show that the invention is not new</p>			
IV. CLERIFICATION			
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report		
18th October 1989	3 Oct 1989		
International Searching Authority	Signature of Authorised Person		
EUROPEAN PATENT OFFICE	T.K. WILLI		

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

GB 8900796
SA 30105

This annex lists the patent family members relating to the patent documents cited in th¹ above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 08/11/89
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family members)	Publication date
FR--A- 2591902 -----	26-06-87	None	-----
'DE-A- 330(1517	26-07-84	None	